The Effects of Banking Digital Competition on Growth and Financial Stability: Evidence from Banking APPs Usership

Abstract: Banks intensively invest in digital transformation. Using unique usership data, we examine the competition implications of mobile banking, a digital technology facilitating nationwide banks' penetration into local markets. Consistent with Dell'Ariccia and Marquez (2004), regional banks' profit decreases with lowered lending rates and deteriorated loan portfolios. In response, they increase risk-taking and reallocate assets to financial investments. In favor of the competition-fragility view, digital competition leads to the weakness of regional banks, expedites their branch closure, and slows down regional credit growth. This study contributes to the bank digitalization literature and informs regulators about the competition effects of mobile banking.

1 Introduction

The banking industry is racing toward the era of digitalization, thanks to the rapid development of information and digital technology. Customers, instead of being restricted to banking locations, are able to use digital channels for transactional activities. Extracting data from Call Reports for US banks, Modi et al. (2022) demonstrate a six-fold increase in bank IT investment from 2001 to 2021. At the end of 2019, median IT investment accounted for 5.1% of banks' net income in the US (Jiang et al., 2022) and 2-3% of their total operational costs in Italy (Branzoli, Rainone, and Supino, 2024). Many senior executives from leading banks have publicly expressed their optimism for going digital.[1][2]

Customers' extensive use of digital services has reshaped banking preferences and behaviors and could have profound implications on credit market competition and banking performance. Although the role of information technology has been extensively examined in banking literature (Kwan et al., 2021; Pierri and Timmer, 2022; Branzoli, Rainone, and Supino, 2024), our paper emphasizes that, unlike traditional IT which facilitates banks' own storage, transmission, and processing of information, digitization technology creates an interactive environment between banks and clients, enabling two-way information exchange. The process efficiently creates and disseminates information, and more importantly, allows banks to solicit clients' information, unbounded by distance restrictions. Specifically, we investigate how banking digital competition affects credit provision and growth, and how it impacts

[1] For example, when accepting the World's Best Digital Bank award issued by Euromoney in 2016, Piyush Gupta, the CEO of DBS Bank, said, "We have spent the past three years deeply immersed in the digital agenda". The awardee of the following year was Citibank, whose CEO, Stephen Bird, proudly stated, "Citi now has more digital users than Amazon Music and more mobile users than Google Play." Francisco González, the CEO of BBVA, also noted, "We have to transform the bank into a digital company as soon as we can."

[2] A survey by Cornerstone Advisor (2021) found that 55% of 300 senior executives from US banks and credit unions had launched a digital transformation strategy by 2021, with only 11% having no plan.

financial stability.

Digitalization brings several potential benefits, such as achieving better economies of scale, reducing operation costs, and more efficient information collection and processing. In theory, the competition implications of digitalization vary, depending on the specific role digital technology plays (Hauswald and Marquez, 2003; Vives and Ye, 2023). Technologies that enable remote communication and alleviate distance friction in lending are pro-competition, as they level the playing field by facilitating new entrants' information collection. Conversely, digitalization that allows incumbent banks to capitalize on their information advantage in loan screening widens the information rent in lending, discourages entry, and thus weakens competition.

Numerous banks have actively employed mobile banking through mobile applications (i.e., apps), allowing distant consumers to create accounts and access digital banking services online. Mobile banking not only efficiently performs simple tasks such as balance checking and transferring payments, but it is also capable of providing complex services like budgeting and expense tracking, as well as financial management solutions through interactions with clients, all at near zero cost.

These interactions reduce distance friction in information collection (Agarwal and Hauswald, 2010) and allow banks to actively solicit credit-sensitive information from users, alleviating the information barrier that large banks face when penetrating local markets. Additionally, large banks possess advantages in the wave of digital transformation due to their stronger financial and human resources, which improves their efficiency more than that of smaller banks. This cost advantage also promotes large bank penetration into local markets, leading to intensified competition (Sengupta, 2007).

Although prospective borrowers can apply for loans through mobile banking, the

loan decisions are still made by the credit management division. Thus, mobile banking does not enhance incumbent banks' market power by improving their information processing in lending.

The research setting is the rapid growth of mobile banking and increasing digital competition in China, whose banking system includes both nationwide and regional banks. Nationwide banks are larger in size and have access to cheaper deposits, whereas regional banks are smaller but possess better borrower information in their localities.

In theory, the reduced distance frictions and information solicited through mobile banking level the playing field between outside banks with a cost advantage (i.e., nationwide banks) and inside banks with an information advantage (i.e., regional banks). This encourages more aggressive competition from distant nationwide banks, which lowers lending rates, worsens regional banks' loan portfolios, and reduces their performance (Dell'Ariccia and Marquez, 2004). These effects are stronger when mobile banking also widens the cost advantage of nationwide banks (Sengupta, 2007). In response to the heightened competition, regional banks increase risk-taking (Wu et al., 2017). They also retreat from the lending market by reallocating assets toward financial investments.

Empirically, we construct a novel dataset from a leading FinTech data vendor that monitors the number of monthly active users (MAUs) of each Chinese bank app from January 2017 to June 2022. For each bank in a given month, its number of MAUs can be further decomposed into 31 provinces, expanding into an app-province-month level panel covering all Chinese mobile banks. The rise of mobile banking changes the competitive landscape. In January 2017, the total user base of all Chinese mobile banks was only 216.88 million. This number increased by 3.278 times, reaching 710.88 million by June 2022. Nationwide banks seized the opportunity and digitally penetrated

local markets more cost-efficiently through mobile banking services. By June 2022, they had acquired 646.495 million digital consumers, contributing 90.94% of the total usership.

Measuring digital competition by the Herfindahl-Hirschman Index (HHI) of MAUs in each province-year, we find the performance of regional banks exhibits a significantly negative relationship with local digital competition intensity. Regional banks' profit lowers by 0.264 standard deviations for every standard deviation increase in digital competition in their local market. The interest rate margin narrows and loan portfolios worsen with digital competition, which explains their lowered performance. Responding to digital competition, regional banks increase their risk-taking and shift their assets from loans to financial investments.

We establish causality with a Bartik-styled instrumental variable (IV) approach. Using bank hiring data from CnOpenData, we first calculate each bank's engagement in developing mobile banking by its mobile banking-related posts. A bank's promotion of mobile banking can have very different competition implications across provinces, depending on the bank's relative importance in that province. We measure a bank's importance in a province by its inverse ranking of MAUs in early times, before the initiation of digital banking competition in 2017. Lastly, for each province-year, we construct the IV for digital competition by summing each bank's mobile banking hirings, weighted by its importance. By assigning a larger weight to the hiring of more important banks, the IV positively predicts the concentration of mobile banking. The variation in the IV comes from differences in weights across provinces, which are exogenous to digital competition.

The IV regression confirms our main findings that mobile banking-enabled digital competition harms regional banks. They obtain lower profit, associated with reduced

lending rates and deteriorated portfolio quality. Facing fierce digital competition, regional banks increase risk-taking and reallocate assets to financial asset investments.

From a policy perspective, it is unclear whether digitalization that allows large banks to penetrate local markets and challenge local banks should be a concern. While replacing less efficient banks with lower-cost ones enhances the efficiency of the banking system, nationwide banks are selective in supplying credit and tend to reject borrowers from segments with high information asymmetry (Clarke et al., 2005; Mian, 2006). As nationwide banks drive regional banks out of the lending market, the aggregated impacts on stability and credit growth remain ambiguous.

As digital competition heightens, regional banks become more unstable, as reflected by increased scrutiny from regulators and expedited branch closures. Regional-level analysis shows that the entry of nationwide banks fails to fully absorb the unmet credit demand resulting from the retreat of regional banks. A standard deviation decrease in *HHI* is associated with RMB1372.8 less bank loan and RMB398.2 reduction in consumer loan per person. This pattern is similar to the repercussions of international banks' penetration into emerging economies (Claessens, Demirgüç-Kunt, and Huizinga, 2001; Sengupta, 2007).

The paper provides a novel measure of bank digital competition. The meaning of digitalization has evolved over time, from ATM placement (Hannan and McDowell, 1984), widespread usage of PCs (Pierri and Timmer, 2022), application of electronic systems (Lewellen and Williams, 2021), investment in IT hardware, software, and services (Kwan et al., 2021), to online banking adoption (Hernandez-Murillo, Llobet, and Fuentes, 2010). We use proprietary data to construct an MAU measure to proxy a bank's adoption of mobile banking, a contemporary digital banking technology that consumers frequently use to interact with banks (Srinivas and Ross, 2018).

The number of MAUs is the equilibrium result of a bank's supply of digital banking services and its consumers' demand for mobile banking. The outcome-based measures differ from input-based measures for digitalization, such as IT expenditure (Modi et al., 2022; Jiang et al., 2022) and the stock of IT capital (Beccalli, 2007; Kwan et al., 2021; Ahnert et al., 2021; Pierri and Timmer, 2022; Branzoli, Rainone, and Supino, 2024). While input-based measures reflect a bank's intention of going digital, the MAU measure better captures its actual progress.

Our digitalization measure also perfectly aligns with theoretical discussions on digitalization and spatial banking competition (Hauswald and Marquez, 2003; Vives and Ye, 2023). Prior research demonstrates how the usage of PCs (Ahnert et al., 2021) and the application of credit scoring models (DeYoung, Glennon, and Nigro, 2008; Beck, Ioannidou, and Schafer, 2018) increase lenders' spatial outreach. Although these technologies facilitate distant communication, they also alter how banks utilize the information collected in loan screening, thus creating greater information rents. Their competition implications are ambiguous in theory.

Our study focuses on mobile banking, a nascent digital technology that facilitates information exchange between banks and users. It aligns with the technology that promotes information dissemination in Hauswald and Marquez (2003) and the technology that reduces distance frictions in Vives and Ye (2023). Results confirm their predictions that mobile banking intensifies banking competition by reducing distance friction and that nationwide banks' digital penetration through mobile banking lowers the performance of regional banks.

Empirically, our paper extends Petersen and Rajan (2002), who demonstrated how impersonal communication technology increases bank-borrower distance in lending. We focus on a specific contemporary impersonal communication technology, mobile

banking, and investigate its competition implications. The findings also add to the empirical literature on digitalization that investigates determinants (Modi et al., 2022), performance implications (Kwan et al., 2021; Pierri and Timmer, 2022; Branzoli, Rainone, and Supino, 2024), and innovation outcomes (Ahnert et al., 2021).

This research is closely related to the research analyzing the repercussions of foreign banks entering emerging markets. During the financial liberalization wave in the 1990s, developing countries in Eastern Europe, Central Europe, Southeast Asia, and Latin America experienced a massive entry of foreign banks (Barth, Caprio, and Levine, 2001). Foreign banks mimic nationwide banks in our setting with their cost advantage gained from the ability to attract deposits globally. Domestic banks are similar to our regional banks, possessing more soft information about local borrowers. Dell'Ariccia and Marquez (2004) and Sengupta (2007) build the theoretical foundation, conjecturing that foreign banks' entry intensifies competition. They cherry-pick more transparent and high-quality borrowers, lowering the loan portfolio and performance of domestic banks. Similar to our findings, fierce competition lowers domestic banks' interest spread (Claessens, Demirgüç-Kunt, and Huizinga, 2001; Martinez-Peria and Mody, 2004) and increases their risk-taking (Wu et al., 2017).

While foreign banks' penetration is facilitated by financial liberalization and deregulation, digital penetration in our study benefits from banks' FinTech adoption, which alleviates distance friction, as in Beck, Ioannidou, and Schafer (2018). Instead of shedding light on financial liberalization, our research informs regulators about the competition consequences of the rise of mobile banking on regional banks. Taking China as an example, it faces increasing turmoil among its regional banks alongside the digital penetration of nationwide banks. Between June 16 and 21, 2024, 40 high-risk

regional Chinese banks ceased operations within seven days,[3] with most merged into larger banks as a peaceful resolution. While we draw evidence from China, the findings apply to many economies with similar hierarchical banking systems consisting of both nationwide and regional banks (e.g., the US, Japan, Korea, and Germany).

Lastly, the paper joins the discussion on the relationship between FinTech lenders and banks (Chu and Wei, 2023). Although all players in our setting are banks, mobile banking technology enables nationwide banks to collect borrower information unbound by distance constraints, mimicking the key feature of FinTech lenders modeled by Vives and Ye (2022). By showing that mobile banking promotes competition between nationwide and regional banks, our paper contributes to the studies on how FinTech lenders may complement (Tang, 2019) or substitute banks (Gopal and Schnabl, 2022).

2 Institutional Background

2.1 Chinese Banking System

Commercial banks in China are organized into four hierarchies. At the very top are the six largest banks, known as the Big 6. These banks are state-owned and very large in size. As of the end of 2023, the total assets of the Big 6 banks range from 14 to 45 trillion RMB, with their combined assets totaling 185.11 trillion RMB, accounting for 44.3% of the banking industry's assets. The Big 6 banks operate nationwide, from top-tier cities to rural areas, and have an unrivaled branch density. Even in less developed and remote provinces, the Big 6 banks still have strong branch coverage compared with local regional banks.

The second hierarchy consists of 12 joint-equity banks. China Merchants Bank and

[3] Retrieved from: https://www.economist.com/finance-and-economics/2024/07/04/why-chinese-banks-are-now-vanishing

Industrial Bank of China are the largest two, with total assets exceeding 10 trillion RMB. The size of the remaining 10 banks ranges from 1.4 to 9.1 trillion RMB. Broadly speaking, joint-equity banks are an order of magnitude smaller than the Big 6 banks. Thus, although their business also has nationwide reach, the geographical distribution is highly unbalanced. For example, Shanghai Pudong Development Bank, headquartered in Shanghai, has a high concentration of physical facilities in the city, with approximately 0.0071 branches and 0.1046 ATMs per 1,000 people. However, its penetration is significantly lower by more than 50% in Beijing (Shenzhen), with only 0.0044 (0.0031) branches and 0.0498 (0.0332) ATMs per 1,000 people. Their branch coverage is even lower in small cities where most regional banks operate. Even though they also have a cost advantage in acquiring deposits, their access to local soft information is weaker than that of regional banks in their locality.

City commercial banks and rural commercial banks are on the third and fourth hierarchies. Both originated from merging regional credit unions, a preliminary form of commercial bank that prevailed in China in the 1980s. The average asset of 308 sampled city and rural commercial banks is 0.192 trillion RMB, which is approximately another order of magnitude smaller than the joint-equity banks.

Despite being smaller in size, their business coverage is highly centered in their headquarters, giving them very deep reach in their locality. Before the rise of mobile banking in 2017, the direct competition between nationwide and regional banks was moderate, with the former relying on hard information to select large borrowers and the latter specializing in funding local borrowers using soft information (Berger et al., 2005).

The main purpose of these regional banks is to fill the local credit shortage in underdeveloped areas, so Chinese regulation only allows them to open branches within

their registered province. The regulation was briefly relaxed between 2006 and 2011, during which regional banks that met strict requirements on capital, profitability, and non-performing loans were allowed to establish new cross-province branches. However, only a very small proportion of local banks developed cross-province business. Among the 308 local banks in the sample, only 24 have extended their operations beyond four provinces, representing approximately 7.8% of the total. On average, each bank operates across roughly 1.7 provinces, reflecting the generally limited geographic expansion of local banks.

The fifth hierarchy includes village and county banks, which serve specific rural villages or towns. According to statistics from the China Banking Association, China has more than 1,600 rural commercial banks. Their average asset totals 2.22 trillion RMB, comparable to the size of a single small joint-equity bank. Our research does not include these tiny banks.

The regional banks in China are experiencing weak profits and high NPL ratios in recent years. In April 2022, four village and county banks in Henan faced solvency issues and failed to meet withdrawal demands, marking the beginning of the turmoil among regional banks. Regional governments attempted to stabilize local banks through capital injection, but the effects are far from satisfactory. For example, although the Liaoning government issued RMB 33.1 billion in special-purpose bonds to recapitalize regional banks, two more went bankrupt in late August.[4]

The China Banking and Insurance Regulatory Commission plans to mitigate the heightened risk through merging regional banks. Between June 16 and 21, 2024, 40 high-risk regional Chinese banks ceased operations through mergers within seven days,

[4] Retrieved from: https://www.scmp.com/economy/china-economy/article/3185163/how-chinas-henan-bank-scandal-threatens-crisis-confidence

and hundreds more are reported to follow.[5, 6] However, combining troubled banks does not solve the fundamental challenge of nationwide banks' penetration. Regional banks still face deteriorating performance and loan portfolios.

2.2 Mobile Banking and MAU

Mobile banking is an important conduit through which consumers obtain banking services. Deloitte surveyed 17,100 banking consumers from 17 countries and found that respondents most frequently interact with banks through mobile and online banking. Twenty-two percent of the surveyed consumers use mobile banking more than 10 times per month, tying with online banking and leading traditional contact centers (1%), ATMs (6%), and bank branches (2%) by remarkable margins (Srinivas and Ross, 2018).

Banks also place great value on their mobile banking usership. For example, China Merchants Bank, the largest joint-equity bank, explicitly states multiple times in its annual reports that it will use MAU as the "north star metric" to guide the digital transformation of its retail banking business. Thanks to China's large internet user base and the success of Alipay and WeChat, which familiarize consumers with digital payment, mobile banking has experienced rapid growth since its inauguration in China.

The rise of mobile banking presents a better opportunity for nationwide banks to expand their business compared to regional banks. Unlike a physical branch that has limited capacity, the excludability of mobile banking is weak. A consumer's access to mobile banking has very limited influence on other consumers' usage, unless the mobile bank is overloaded by a sudden traffic spike. Therefore, nationwide banks benefit more from this new digital technology due to their larger user base (De Ritter, 2024). Additionally, the larger size of nationwide banks allows them to assemble more

[5] Retrieved from: https://www.economist.com/finance-and-economics/2024/07/04/why-chinese-banks-are-now-vanishing

[6] Retrieved from: https://www.bloomberg.com/news/articles/2024-01-31/china-merges-hundreds-of-rural-banks-as-financial-risks-mount?embedded-checkout=true

resources and invest more in digital transformation (Modi et al., 2022). Data from a three leading online hiring platform in China, 51job.com, zhaopin.com, and liepin.com, show that nationwide banks on average post 92.46 mobile banking-related job openings per bank per year, which is about 68.43 times larger than that of regional banks. In our sample, nationwide banks contribute 86.602% of the increase in MAUs.

3 Hypotheses

As discussed in the institutional background, regional banks operate locally and have a higher branch density and information advantage in the local credit market. Nationwide banks possess a cost advantage due to their large size and access to cheaper deposits through their countrywide business reach. Despite having cheaper funding sources, nationwide banks' ability in client acquisition (Degryse and Ongena, 2005) and loan origination (Nguyen, 2019) is restricted by their inferior branch coverage in local markets. Before the rise of mobile banking, nationwide banks faced high information barriers in penetrating local markets (Bofondi and Gobbi, 2006). Mobile banking technology changed the competitive landscape and potentially benefits nationwide banks in three ways.

First, mobile banking reduces distance frictions in the credit market (Hauswald and Marquez, 2003). Distance friction affects the accuracy of borrowers' signals in loan screening (Hauswald and Marquez, 2006). As bank-borrower distance increases, information asymmetry becomes more severe (Herpfer, Mjos, and Schmidt, 2023), and loan default rates go up (DeYoung, Glennon, and Nigro, 2008; Rajan, Seru, and Vig, 2015). Empirical results using various datasets agree that distance is a deterrent to lending (Brevoort and Hannan, 2006; Agarwal and Hauswald, 2010; Nguyen, 2019).

Mobile banking is the "communication technology that facilitates remote

information collection and exchange, reducing the friction caused by lender-borrower physical distance" (Vives and Ye, 2023, p. 14). Through mobile banking, banks can serve distant consumers and obtain their checking and transaction information (Puri, Rocholl, and Steffen, 2017), which they can utilize in loan screening and pricing (Degryse and van Cayseele, 2000; Cole, Goldberg, and White, 2004; Agarwal and Hauswald, 2010; Puri, Rocholl, and Steffen, 2011).

Second, mobile banking generates information that facilitates lending decisions. Regional banks obtain a prospective borrower's proprietary information through repeated interactions (Boot, 2000). This type of information becomes less informative when taken out of its original context (Liberti and Petersen, 2019). Due to their hierarchical structure, nationwide banks are at a disadvantage in utilizing such information (Stein, 2002; Berger et al., 2005).

Mobile banking creates an interactive environment for its clients, such as providing personalized budgeting and expense tracking solutions, tailor-made financial management advice, and promoting loan products that match their credit demand. Through such interactions, mobile banks solicit a broad range of clients' information, both soft and hard, which is otherwise unavailable to nationwide banks.

Lastly, the digitalized solution reduces costs and widens nationwide banks' cost advantage. Although a balanced cost reduction does not affect bank competition (Vives and Ye, 2023), larger banks tend to have stronger engagement in mobile banking (Modi et al., 2022). Compared to regional banks, large banks have stronger financial and human resources that support digital transformation. At the same time, the informational economies of scale (Brynjolfsson, 1994) give large banks a stronger incentive to promote mobile banking. Consequently, nationwide banks reduce costs to a larger scale through mobile banking.

Both better information and greater cost advantage facilitate the digital penetration of nationwide banks into local markets (Sengupta, 2007), and we rationalize the competition implications of mobile banking under the banking competition framework of Dell'Ariccia and Marquez (2004) as well as Sengupta (2007). Both models illustrate the competition between inside banks with local expertise and potential new entrant banks that possess cost advantages, with the former focusing more on information asymmetry and the latter providing additional insights on cost advantage.

By facilitating distant information collection, mobile banking reduces the informational gap between nationwide banks and regional ones. With better access to local borrowers' information through mobile banking, nationwide banks can better differentiate opaque borrowers that are difficult to assess from lemons denied by regional banks, thereby alleviating adverse selection. The leveled playing field weakens the informational barrier that obstructs nationwide banks' entry into local markets (Bofondi and Gobbi, 2006), intensifying digital banking competition and lowering the profit of regional banks.

Their models uncover two channels through which digital banking competition affects the performance of regional banks. The alleviated information asymmetry allows nationwide banks to better capitalize on their cost advantage and cut interest rates in lending. This is particularly true when mobile banking widens nationwide banks' cost advantage. To retain borrowers who receive loan offers from nationwide banks, regional banks need to lower their interest rates to match those of the nationwide banks.

Apart from the lending rate channel, digital banking competition also lowers the quality of regional banks' loan portfolios. Dell'Ariccia and Marquez (2004) highlight regional banks' own credit reallocation decision, "flight to captivity." As relationship borrowers are more captured (i.e., captive borrowers) and have less elastic demand for

loans, regional banks retain more of them when facing nationwide banks' digital penetration. Because captive borrowers, on average, are younger and smaller local firms of lower quality, regional banks' flight to captivity predicts a worsened portfolio.

Sengupta (2007) emphasizes the cream skimming of nationwide banks and predicts the same. In his model, nationwide banks only obtain high-risk borrowers when their cost advantage is small. However, as their cost advantage goes up, they are able to fully finance all borrowers from high-quality market segments. The cherry-picking of high-quality segments also predicts a deterioration of regional banks' loan portfolios.

We summarize the influence of digital competition on regional banks as the first set of hypotheses:[7]

H1a (Performance): Digital competition lowers the profit of regional banks.

H1b (Interest Rate): Digital competition lowers the lending rate of regional banks.

H1c (Portfolio Quality): Digital competition lowers the portfolio quality of regional banks.

Facing the narrowed interest rate margin, regional banks have two options. To stay in the lending market, regional banks may chase yield and increase their risk-taking (Wu et al., 2017). This is particularly true in China, where the downside risk is explicitly protected by deposit insurance (Keeley, 1990) and implicitly covered by government aids (Duchin and Sosyura, 2014).

Banks make both interest and non-interest income. Therefore, regional banks can alternatively respond to the heightened competition by shifting towards non-interest income, generated from trading, commissions, and investments. The retreat of regional

[7] We develop these hypotheses within the banking competition framework. Theories on bank IT investment predict similar repercussions of the rise of mobile banking. Modeling *information dissemination IT* as the technology that allows less informed banks to obtain borrowers' public information, Hauswald and Marquez (2003) show that it reduces the insider banks' information advantage and leads to lowered loan rates and performance. Similarly, Vives and Ye (2023) demonstrate that IT that alleviates distance frictions reduces lender differentiation, thus increasing competition and decreasing lender profit.

banks from the lending market predicts a reallocation of assets towards financial assets, such as treasuries, corporate bonds, and equity holdings. As non-interest incomes, on average, are more volatile, empirical evidence also associates a diversified bank income structure with higher risk (Stiroh, 2006; Lepetit et al., 2008). The second set of hypotheses summarizes regional banks' responses to digital competition:

H2a (Risk Taking): Regional banks increase their risk-taking facing intensified digital banking competition.

H2b (Asset Allocation): Regional banks increase their net positions in financial investments facing intensified digital banking competition.

4 Data and Methodology

4.1 Digital Competition

We measure each bank's mobile banking development by its mobile app usership. The data come from a proprietary data vendor that monitors the user base of all mobile apps with a minimum of 500 MAUs in China. In our sample, the average MAU for nationwide and regional banks is about 25.92 million and 0.41 million, respectively. Compared to the large digital user base, 500 MAUs is a very low selection criterion. Banks that fail to pass this threshold are trivial players with little impact on digital competition. The proprietary dataset includes the monthly number of MAUs of 171 apps belonging to 140 Chinese commercial banks. For banks with multiple separate lines of business into multiple apps,[8] we measure their usership as the sum of the apps' MAUs.

[8] For example, Bank of China provides comprehensive banking services, credit card services, and corporate banking services through the Bank of China app, the Bank of China Joy Life app, and the Bank of China Corporate Banking app, respectively.

The standard data structure is a monthly panel of MAUs by bank app. We customized the service to decompose each app's monthly number of MAUs into 31 provinces. Although Chinese authorities maintain strict control over cross-province entry of regional banks, restrictions on their expansion within a province have been lifted. Banks in one city provide substantial services to other cities, making the province the geographic unit of banking competition. As bank accounting variables are at annual frequency, we conduct the empirical analysis on an annual basis, so we aggregate the monthly MAUs into yearly levels, resulting in an app-province-year level panel spanning from 2017 to 2022.

The measure of digital competition intensity is the HHI of banks' MAUs within each province and year. As the majority of regional banks operate within a province, the baseline analysis only considers a regional bank's headquarters location and directly uses the *HHI* of its locality to proxy digital competition.

We also consider the geographical business expansion of regional banks and proxy their competition environment with the weighted average HHI within their business outreach (Akins et al., 2016). Specifically, for bank *i* in year *t*, we define $W_HHI_{it} = \sum_p \frac{MAU_{pt}}{MAU_{it}} * HHI_{pt}$, where HHI_{pt} is the *HHI* of province *j* in year *t*. And the weights are bank *i*'s MAU in province *p* over its total MAU. In robustness test, we define the concentration ratio, *CR_6*, which is the combined MAU share of the Big 6 banks in a province.

Figure 1 plots the evolution of the number of MAUs of all banks (on the left axis) over time. In addition, we present the percentage of nationwide banks' MAUs on the right axis. The solid line represents the average of nationwide banks' MAU shares across all provinces, whereas the dashed line indicates nationwide banks' MAU share over the country, calculated as nationwide banks' MAU divided by the total MAU of

all banks in China. The total MAU was only 216.88 million in January 2017, but has increased more than three times, reaching 710.88 million in June 2022. Nationwide banks contribute the majority of mobile banking usership, with their MAU shares expanding over time. This increase is more pronounced for the MAU shares for China as a whole (i.e., dashed line), suggesting that digital penetration is a nationwide phenomenon, rather than within some provinces. The pattern confirms the dominant role of nationwide banks, and their penetration into local markets contributes to the intensified digital banking competition.

[Insert Figure 1 here]

Table 1 presents the descriptive information about the banks' digital competition across China's 31 provinces over the sample period. There is significant variation in MAU, the number of banks providing mobile banking services, the percentage of nationwide banks, and *HHI* across provinces.

More economically developed provinces like Guangdong, Zhejiang, and Jiangsu demonstrate the highest MAU levels, reaching 977.02 million, 641.48 million, and 696.26 million respectively. In contrast, provinces with smaller populations or less economic development, such as Qinghai and Tibet, display considerably lower MAU totals, with 21.95 million and 13.51 million respectively.

As of 2022, nationwide banks shape the digital competition landscape, with exceptionally high contributions of MAU across provinces. Nationwide banks account for over 90% of MAU in most regions, with provinces such as Fujian and Guangdong seeing contributions as high as 96.55% and 95.00% respectively. Furthermore, Big 6 banks also maintain a strong foothold, particularly in Zhejiang, where they contribute 68.81% of MAU. These figures highlight the overwhelming dominance of national and large banks in shaping the competitive environment, underscoring their pivotal role in

driving digital banking competition across China.

Although the number of banks varies significantly across provinces, ranging from as high as 142 in Shandong to as few as 19 in Tibet, their influence on digital competition appears limited. The competition is predominantly driven by nationwide banks, as evidenced by the relatively low market shares of regional banks, even in provinces with a higher number of local institutions. For instance, in provinces such as Jiangxi and Hebei, despite having over 100 regional banks, the percentage of nationwide banks remains high, reinforcing the notion that digital competition is largely dominated by larger, nationwide banks rather than regional ones.

The last two columns present the most direct competition measure, *HHI* in 2022 and 2017. The digital competition landscape also varies across provinces. In 2022, Jiangsu has the lowest HHI of 0.087, followed by Hainan, Henan, Anhui, and Shanghai. The digital banking market in Tibet is most concentrated with the highest HHI of 0.152.

Almost all provinces experience a decrease in HHI from 2017 to 2022, with Tibet being the only exception. On average, HHI lowers by 0.032 (21.46% compared to means), indicating a remarkable intensification of digital competition. Provinces such as Hebei, Jilin, and Xinjiang exhibit the most pronounced declines in HHI, with average decreases of 0.035, 0.051, and 0.057 respectively.

[Insert Table 1 Here]

4.2 Research Design

Bank financial data are from CSMAR, covering 375 regional banks. We exclude 67 banks for missing key variables in our sample period, and the baseline analysis includes 308 regional banks. Model (1) below uses the regional bank sample to examine a bank's performance in relation to digital banking competition in their locality.

$$Performance_{it} = \beta_0 + \beta_1 HHI_{it} + \beta_2 Controls_{it-1} + \theta_i + \mu_t + \varepsilon_{it} \quad (1)$$

$Performance_{it}$ is a set of bank performance measures including net income over assets (*NETINCTA*), net interest margin (*NIM*) and provision coverage ratio (*PVCRA*). HHI_{it} is the digital competition status of the regional bank's headquartered province.

The model follows the empirical setting of Detragiache, Tressel, and Gupta (2008) and controls for bank *i*'s characteristics, the economic and financial status of the province where bank *i* is located. Bank level controls includes overhead cost to total assets (*OHTA*), loan to asset (*LTA*), logarithm of bank asset (*Asset*), and capital adequacy ratio (*CAR*). The models also use provincial GDP per capita (*PGDP*) and GDP growth rate (*GGDP*) to control for regional economic conditions. θ_i and μ_t represent year and bank fixed effects, respectively. All control variables are lagged by 1 year.

To test the second set of hypotheses on the retreat of regional banks from the lending market, we replace the dependent variables with $Response_{it}$, including *Z-score* that proxies risk-taking (Bhagat, Bolton, and Lu, 2015), and *FINATA* defined as a bank's financial investment amount over assets. All bank-level analyses cluster standard errors at the bank level. Appendix 1 reports the definition of all variables.

4.3 Summary Statistics

Panel A and Panel B of Table 2 respectively present various bank-level and province-level variables. On average, banks earn a net income of 7% of their total assets (NETINCTA), enjoy a net interest margin (NIM) of 2.5%, and have a provision coverage ratio (PVCRA) of 2.65. At the province level, the average HHI is 0.125, with a standard deviation of 0.022.

Panel C compares the performance and characteristics between nationwide banks and regional banks. The last two columns display the difference in means and medians with statistical significance. Nationwide banks outperform regional banks with a

significantly higher net income over assets (*NETINCTA*). However, the provision coverage ratio (*PVCRA*) is higher for regional banks. One possible explanation is that regional banks allocate significantly more assets to financial investments (*FINATA*) than nationwide banks. Their higher provision coverage ratio could be driven by a smaller denominator. Nationwide banks' higher loan to asset ratio (*LTA*) is also in line with the above conjecture. Nationwide banks are safer and larger, as reflected by a higher *Z-score* and larger *Asset*. The capital adequacy ratio (*CAR*) does not vary significantly between two types of banks.

[Insert Table 2 Here]

5 Empirical Results

5.1 Digital Competition and Regional Bank Performance

Table 3 presents the impacts of digital competition on the performance of regional banks. The dependent variables are net income over assets (*NETINCTA*), net interest margin (*NIM*), and provision coverage ratio (*PVCRA*). The focal variable, *HHI*, is significantly positive in specifications (1) and (2) where the dependent variable is *NETINCTA*, showing that more intensive digital competition is associated with lowered performance of regional banks. The magnitudes of the effects of digital competition are not trivial: a one standard deviation decrease in HHI lowers a regional bank's net income by 0.264 standard deviations.

The significantly positive coefficients of *HHI* across specifications (3) to (6) indicate that digital competition raises loan defaults and narrows the net interest margin (*NIM*) of regional banks, which justifies their worsened performance. Increasing digital competition by one standard deviation would lower the provision coverage ratio by 0.266 standard deviations and reduce the net interest margin by 0.156 standard deviations.

[Insert Table 3 Here]

5.2 Digital Competition and Regional Bank Response

The dependent variables in Table 4 are the bank's *Z-score* and financial investment over assets (*FINATA*) in the first and last two specifications, respectively. As digital competition intensifies, regional banks increase their risk-taking, as reflected by the positive coefficients of *HHI* in specifications (1) and (2). At the same time, they retreat from the lending market and reallocate assets towards financial investments. The negative coefficients of the focal variable in specifications (3) and (4) show a positive relationship between competition and regional banks' holding of financial assets.

[Insert Table 4 Here]

5.3 Endogeneity and identification

The above results are correlational and may be subject to endogeneity concerns. The first source of endogeneity is reverse causality. Bank performance is a key determinant of its digital transformation decision, which in turn affects digital banking competition.

More importantly, the results could be contaminated by omitted variables. Provinces with better economic development tend to have more advanced IT infrastructure, such as greater coverage of 5G base stations. This IT infrastructure encourages banks to engage in digital transformation, creating stronger regional digital competition. At the same time, bank performance is highly correlated with local economic conditions. Although the model includes regional controls, they cannot fully absorb their influence. Thus, our competition measures could also capture the influence of local economic development, biasing the estimated coefficients upward against us.

We establish causality with a Bartik-styled IV. The relative importance of 18 nationwide banks varies significantly across provinces. For example, China Guangfa Bank, headquartered in Guangdong Province, is the 7th most important bank in

Guangdong in terms of MAUs, but it only ranks 18th in Shandong Province. Therefore, when China Guangfa Bank promotes its mobile banking, the competition implications are very different. With a highly (less) important bank increasing its penetration, the digital banking market becomes more (less) concentrated in Guangdong (Shandong). The variations in the relative importance of the 18 nationwide banks across provinces provide an opportunity to identify the exogenous part of digital competition in each province. Below, we explain the construction of our IV and elaborate on how it captures the exogenous changes in regional digital competition.

First, for each bank-year, we measure its engagement in developing mobile banking through its hiring of mobile banking-related talents (Babina et al., 2024). CnOpenData provides the complete bank hiring posts on 51job.com, zhaopin.com, and liepin.com, the three leading Chinese online hiring platforms. A posting is mobile banking-related if its job description includes mobile banking-related keywords listed in Appendix II. We measure a bank's relative effort in promoting mobile banking development by its number of mobile banking posts, rescaled by the total number of mobile banking posts ($Mobile_Hiring_{it}$). A higher value of $Mobile_Hiring_{it}$ indicates that bank *i* devotes more resources to promoting its mobile banking in year *t*.

Second, for the relative importance of bank *i* in province *p*, we construct the measure ω_{ip} as the reverse ranking of bank *i*'s MAUs in January 2017, when mobile banking in China was still in its early stages. For example, ω_{ip} equals 18 for the bank with the highest MAUs in January 2017 in province *p*, and 1 for the bank with the smallest MAUs. As discussed in the previous illustrative example of China Guangfa Bank in Guangdong and Shandong, ω_{ip} has large variations within the same bank but across provinces.

Facing fierce competition from Alipay and WeChat Pay in the digital payment

market, China's nationwide banks first started to allocate resources to develop their own mobile apps.[9] Therefore, ω_{ip} calculated using MAU data in January 2017 reflects the natural business span of bank i in province p, unaffected by each bank's subsequent efforts in promoting mobile banking.

Lastly, we build the IV for the province-year level digital competition measures as follows:

$$Hiring_Concentration_{pt} = \sum_{i=1}^{18} Mobile_Hiring_{it} * \omega_{ip} \quad (2)$$

For each province-year, we sum the *Mobile_Hiring* of 18 nationwide banks, using each bank's relative importance in that province as a weight. When the relatively larger banks hire more mobile banking talents, the IV is larger. Consequently, the digital banking market tends to be more concentrated. Our IV thus satisfies the relevance condition, and we expect it to be positively related to *HHI*.

Although hiring is an endogenous decision, the cross-sectional variations in our IV stem from each bank's relative importance ω_{ip}. Because the bank rankings are very different across provinces, aggregating banks' *Mobile_Hiring* with dissimilar weights produces distinct values of IV across provinces. As ω_{ip} derives from early MAU records, it is exogenous to the digital competition that started to intensify from 2017. The IV allows us to identify the exogenous part of changes in competition measures, therefore complying with the exclusion restrictions.

Table 5 presents the first stage regression results in the first column, where the dependent variable is *HHI*. The IV is positively loaded as expected. The coefficient is highly significant with an F-statistic greater than 10. Kleibergen-Paap Wald statistics are much larger than Stock and Yogo thresholds, confirming the validity of the IV.

[9] Retrieved from: https://www.wsj.com/articles/chinas-banking-giants-try-to-snatch-share-of-mobile-payments-1484042953

columns (2) to (6) report the second stage regression results using bank performance and responses measures as dependent variable. The instrumented HHI ($\widehat{HHI}$) exhibits the same sign as in Table 3 and 4, and remains statistically significant at convention levels.

[Insert Table 5 Here]

The IV regressions establish causality and confirm our hypotheses. Digital competition worsens regional banks' performance by lowering lending rates and deteriorating loan portfolios. In response to heightened digital competition, regional banks increase risk-taking and shift assets towards financial investments.

5.4 Stability and Growth Implications

This section extends the main analysis and discusses the stability and growth implications of mobile banking-enabled digital banking competition. Panel A of Table 6 focuses on regional banks' closures of branches, which have a strong and persistent negative influence on local credit supply (Nguyen, 2019). The impacts are particularly relevant to regional banks that rely on branch coverage to serve relationship lenders. We obtain bank branch data from CNRDS and replace the dependent variable in Model (1) with CLOSURE, defined as the percentage of branches closed of each bank in a given year. Columns (1) and (2) of Panel A report the baseline regression results following Eq. (1). The IV estimation using the 2SLS method is reported in Columns (3) and (4).

HHI exhibits significantly negative coefficients across all specifications, meaning that heightened digital competition accelerates branch closures of regional banks. Quantitatively, a standard deviation increase in *HHI* expedites their branch closure by 0.31 percentage points. The 2SLS results with instrumental variables also consolidate

the results.[10]

The banking industry is highly regulated. Regulatory enforcement provides an objective measure of the weakness of a specific institution. By manually collecting enforcement data from the China Banking and Insurance Regulatory Commission, we define *SCRUTINY* as the number of violations detected by regulatory authorities in a given year, scaled by the number of employees. Columns (1) and (2) of Panel A substitute the dependent variable of Eq. (1) with *SCRUTINY*. The IV estimation using the 2SLS method is reported in Columns (3) and (4) of Panel A.

The negative coefficients of *HHI* demonstrate a positive relationship between digital competition and regulatory scrutiny. The results are not surprising considering the deteriorated performance, worsened portfolio, increased risk-taking, and asset reallocation of local banks. More importantly, the pattern echoes the recent turmoil in China's regional banking sector.

[Insert Table 6 Here]

Next, we turn to the implications of regional credit growth. The theoretical predictions are ambiguous. On one hand, the replacement of less efficient banks with better-managed and lower-cost ones enhances the overall performance of the credit system (Jayaratne and Strahan, 1998). Digital penetration may absorb unmet credit demand and improve credit availability (Giannetti and Ongena, 2005; Avramidis, Mylonopoulos, and Pennacchi, 2022). On the other hand, the new entrant banks that rely on hard information tend to cherry-pick the high-quality market segments (Sengupta, 2007) and ignore smaller local borrowers (Clarke et al., 2005; Mian, 2006). Therefore, heightened digital competition could reduce the credit supply to local firms

[10] The bank-branch data start from 2017. Thus, the bank branch closure information is only available after 2018, leading to a missing sample size.

(Detragiache, Tressel, and Gupta, 2008; Gormley, 2010).

Wisdom from foreign bank entry provides insights to reconcile the mixed predictions on credit supply. In both Claessens, Demirgüç-Kunt, and Huizinga (2001) and Sengupta (2007), the entry of foreign banks increases credit supply when the incumbent banks possess a cost advantage. However, if foreign banks are able to provide cheaper credit, their entry and the intensified competition impose adverse impacts on credit supply. Given the cost advantage of nationwide banks, our setting mimics the latter case.

The regional analysis in Model (3) formally examines the influence of digital competition on regional credit growth:

$$Credit_{pt} = \beta_0 + \beta_1 HHI_{it} + \beta_2 Controls_{pt-1} + \theta_p + \mu_t + \varepsilon_{pt} \qquad (3)$$

The dependent variables consist of two province-level loan amount measures from the CEIC database. The first one is the total outstanding bank loan amount (in 10 thousands RMB) rescaled by population (*LoanAMT*). Additionally, we examine the growth in consumer loans, a typical type of uncollateralized credit characterized by high information asymmetry that large banks tend to avoid (Sengupta, 2007). *CLoanAMT* is the total outstanding consumer loan amount (in 10 thousands RMB) rescaled by population. Our focal variable is the provincial digital competition measure, *HHI*. The provincial control variables include GDP per capita (*PGDP*), GDP growth rate (GGDP), the value added of the tertiary industry over GDP (*GIND*), price growth index (GPRICE), and fixed asset investment growth rate (*GINVEST*). We also follow Fan, Wang, and Ma (2012) and control for the marketization index of each province (*Market*). θ_p and μ_t are province fixed effects and year fixed effects, respectively.

Table 7 presents the OLS regression results confirming our conjecture that intensified digital competition is related to credit contraction, with strong economic

significance. A standard deviation decrease in *HHI* is associated with RMB1372.8 less bank loan and RMB398.2 reduction in consumer loan per person. Although digital competition has the potential to improve the efficiency of the banking system, heightened competition is associated with reduced credit growth. The pattern is in line with the findings of foreign banks' entry into emerging markets (Demirgüç-Kunt and Huizinga, 2001; Sengupta, 2007). The digital penetration of nationwide banks into local markets crowds out regional banks from the lending market; however, they fail to fully absorb the credit demand that used to be satisfied by regional banks. Consequently, regional access to credit worsens.

[Insert Table 7 Here]

6 Robustness Tests

6.1 Alternative Competition Measures

Although IV regressions alleviate reverse causality and omitted variable concerns, measurement errors may create biases, especially for regional banks that operate across provinces. The focal variable, *HHI*, in the baseline analysis is based on a regional bank's headquarters. But banks with business spanning multiple provinces face various digital competition in different regions.

Motivated by Akins et al. (2016), Table 8 Panel A uses the weighted HHI, *W_HHI*, as an alternative competition proxy. For regional banks that only operate within their headquartered province, *W_HHI* equals *HHI*. Among the 103 regional banks with cross-province business coverage, 70 have mobile banks, allowing us to assign weights across provinces and construct their weighted competition proxy. However, we lose observations from 33 banks that operate in multiple provinces but do not have mobile banking services.

Panel B replaces *HHI* with the concentration ratio, *CR_6*, which is the sum of

MAU shares of the Big 6 banks. A higher value of *CR_6* indicates a more concentrated digital banking market structure. Similar to *HHI*, *CR_6* is also a reverse measure of competition.

Both panels use the banks' performance measures as dependent variables in specifications (1) to (3), and response indicators in specifications (4) and (5). The results are consistent with our main findings that digital competition lowers regional banks' profit, increases their risk-taking, and drives them out of the lending market.

[Insert Table 8 Here]

6.2 Alternative Performance and Response Measures

In Table 9, the first specification uses *ROE* to reflect each bank's profitability. Specification (2) replaces the provision coverage ratio (*PVCRA*) with the non-performing loan ratio (*NPL*). Specification (3) uses profit volatility to proxy bank risk-taking. In particular, we define *SD_NETINCTA* as the three-year backward-looking standard deviation of *NETINCTA*. The last specification examines how regional banks reallocate assets away from lending and uses the growth rate of loan amount outstanding (*GLOAN*) as the dependent variable.

Our findings are robust to the use of alternative bank performance and response measures. Regional banks experience worsened loan portfolio quality and deteriorated performance. In response, they increase risk-taking to chase for yield and shift more assets to financial investment.

[Insert Table 9 Here]

7 Conclusions

Using a unique bank-province-month panel of the number of MAUs for all Chinese banks, we construct a digital banking competition measure and examine how digital

banking competition affects regional banks that specialize in serving local clients. Mobile banking creates an interactive environment between banks and their clients, thus reducing distance friction, facilitating the solicitation of credit-sensitive information, and reducing costs. This emerging technology allows nationwide banks to penetrate local markets, where they lack the strong branch coverage that local banks have.

In line with the model predictions of Dell'Ariccia and Marquez (2004), the rise of mobile banking and intensified digital competition worsen the performance of regional banks due to narrowed interest margins and deteriorated loan portfolios. Digital competition drives regional banks out of the lending market, leading them to allocate more assets to financial instruments in response to the penetration of nationwide banks. These findings are robust to Bartik-styled IV regressions that address endogeneities associated with omitted variables and reverse causality.

This paper contributes to the bank digitalization literature by proposing a novel and contemporary digital transformation measure based on mobile banking usership. We provide the first description of banks' intensive adoption of mobile banking and examine its competition implications.

The findings are also valuable to regulators facing the disruption of mobile banking. Our research setting, China, is experiencing turmoil in its banking sectors. Alongside the rise of digital banking, regional banks are failing and retreating from the lending market. Countries with similar hierarchical banking systems, such as the US, Japan, Korea, and Germany, may face similar challenges. Our research warns these regulators about the competition and stability implications of mobile banking.

Reference

Agarwal, S., & Hauswald, R. (2010). Distance and private information in lending. *The Review of Financial Studies*, *23*(7), 2757-2788.

Ahnert, T., Doerr, S., Pierri, M. N., & Timmer, M. Y. (2021). *Does IT help? Information technology in banking and entrepreneurship*. International Monetary Fund. *Available at* https://www.imf.org/-/media/Files/Publications/WP/2021/English/wpiea2021214-print-pdf.ashx

Akins, B., Li, L., Ng, J., & Rusticus, T. O. (2016). Bank competition and financial stability: evidence from the financial crisis. *Journal of Financial and Quantitative Analysis*, *51*(1), 1-28.

Avramidis, P., Mylonopoulos, N., & Pennacchi, G. G. (2022). The role of marketplace lending in credit markets: Evidence from bank mergers. *Management Science*, *68*(4), 3090-3111.

Babina, T., Fedyk, A., He, A., & Hodson, J. (2024). Artificial intelligence, firm growth, and product innovation. *Journal of Financial Economics*, *151*, 103745.

Barth, J. R., Caprio, G., & Levine, R. (2001). *The regulation and supervision of banks around the world: A new database* (Vol. 2588). World Bank Publications.

Beccalli, E. (2007). Does IT investment improve bank performance? Evidence from Europe. *Journal of Banking & Finance*, *31*(7), 2205-2230.

Beck, T., Ioannidou, V., & Schäfer, L. (2018). Foreigners vs. natives: Bank lending technologies and loan pricing. *Management Science*, *64*(8), 3792-3820.

Berger, A. N., Miller, N. H., Petersen, M. A., Rajan, R. G., & Stein, J. C. (2005). Does function follow organizational form? Evidence from the lending practices of large and small banks. *Journal of Financial Economics*, *76*(2), 237-269.

Bhagat, S., Bolton, B., & Lu, J. (2015). Size, leverage, and risk-taking of financial institutions. *Journal of Banking & Finance*, *59*, 520-537.

Bofondi, M., & Gobbi, G. (2006). Informational barriers to entry into credit markets. *Review of Finance*, *10*(1), 39-67.

Boot, A. W. (2000). Relationship Banking: What Do We Know? *Journal of Financial*

Intermediation, *9*(1), 7-25.

Branzoli, N., Rainone, E., & Supino, I. (2024). The role of banks' technology adoption in credit markets during the pandemic. *Journal of Financial Stability*, *71*, 101230.

Brevoort, K. P., & Hannan, T. H. (2006). Commercial lending and distance: evidence from Community Reinvestment Act data. *Journal of Money, Credit and Banking*, 1991-2012.

Brynjolfsson, E. (1994). Information assets, technology and organization. *Management Science*, *40*(12), 1645-1662.

Chu, Y., & Wei, J. (2023). Fintech Lending and Credit Market Competition. *Journal of Financial and Quantitative Analysis*, 1-27.

Claessens, S., Demirgüç-Kunt, A., & Huizinga, H. (2001). How does foreign entry affect domestic banking markets?. *Journal of Banking & Finance*, *25*(5), 891-911.

Clarke, G., Cull, R., Peria, M. S. M., & Sánchez, S. M. (2005). Bank lending to small businesses in Latin America: Does bank origin matter?. *Journal of Money, Credit and Banking*, 83-118.

Cole, R. A., Goldberg, L. G., & White, L. J. (2004). Cookie cutter vs. character: The micro structure of small business lending by large and small banks. *Journal of Financial and Quantitative Analysis*, *39*(2), 227-251.

Cornerstone Advisor. (2021). What's going on in banking 2022. Available at: https://f.hubspotusercontent40.net/hubfs/166442/Whats-Going-On-In-Banking-2022_Cornerstone-Advisors.pdf

Degryse, H., & Van Cayseele, P. (2000). Relationship lending within a bank-based system: Evidence from European small business data. *Journal of Financial Intermediation*, *9*(1), 90-109.

Degryse, H., & Ongena, S. (2005). Distance, lending relationships, and competition. *The Journal of Finance*, *60*(1), 231-266.

Detragiache, E., Tressel, T., & Gupta, P. (2008). Foreign banks in poor countries: Theory and evidence. *The Journal of Finance*, *63*(5), 2123-2160.

Dell'Ariccia, G., & Marquez, R. (2004). Information and bank credit

allocation. *Journal of Financial Economics*, *72*(1), 185-214.

De Ridder, M. (2024). Market power and innovation in the intangible economy. *American Economic Review*, *114*(1), 199-251.

DeYoung, R., Glennon, D., & Nigro, P. (2008). Borrower–lender distance, credit scoring, and loan performance: Evidence from informational-opaque small business borrowers. *Journal of Financial Intermediation*, *17*(1), 113-143.

Duchin, R., & Sosyura, D. (2014). Safer ratios, riskier portfolios: Banks' response to government aid. *Journal of Financial Economics*, *113*(1), 1-28.

Fan, G., Wang, X., & Ma, G. (2012). The contribution of marketization to China's economic growth. *China Economist*, *7*(2), 4.

Giannetti, M., & Ongena, S. (2005). Financial integration and entrepreneurial activity: Evidence from foreign bank entry in emerging markets. *Available at SSRN 726692*.

Gopal, M., & Schnabl, P. (2022). The rise of finance companies and fintech lenders in small business lending. *The Review of Financial Studies*, *35*(11), 4859-4901.

Gormley, T. A. (2010). The impact of foreign bank entry in emerging markets: Evidence from India. *Journal of Financial Intermediation*, *19*(1), 26-51.

Hannan, T. H., & McDowell, J. M. (1984). The determinants of technology adoption: The case of the banking firm. *The RAND Journal of Economics*, 328-335.

Hauswald, R., & Marquez, R. (2003). Information technology and financial services competition. *The Review of Financial Studies*, *16*(3), 921-948.

Hauswald, R., & Marquez, R. (2006). Competition and strategic information acquisition in credit markets. *The Review of Financial Studies*, *19*(3), 967-1000.

Hernández-Murillo, R., Llobet, G., & Fuentes, R. (2010). Strategic online banking adoption. *Journal of Banking & Finance*, *34*(7), 1650-1663.

Herpfer, C., Mjøs, A., & Schmidt, C. (2023). The causal impact of distance on bank lending. *Management Science*, *69*(2), 723-740.

Jayaratne, J., & Strahan, P. E. (1998). Entry restrictions, industry evolution, and dynamic efficiency: Evidence from commercial banking. *The Journal of Law and Economics*, *41*(1), 239-274.

Jiang, S., He, Z., Yin, X., & Xu, D. (2022). Investing in lending technology: It spending in banking. *Available at SSRN 3936084*.

Keeley, M. C. (1990). Deposit insurance, risk, and market power in banking. *The American Economic Review*, *80*(5), 1183-1200.

Kwan, A., Lin, C., Pursiainen, V., & Tai, M. (2021). Stress testing banks' digital capabilities: Evidence from the COVID-19 pandemic. *Journal of Financial and Quantitative Analysis*, 1-29.

Lepetit, L., Nys, E., Rous, P., & Tarazi, A. (2008). Bank income structure and risk: An empirical analysis of European banks. *Journal of Banking & Finance*, *32*(8), 1452-1467.

Lewellen, S., & Williams, E. (2021). Did technology contribute to the housing boom? Evidence from MERS. *Journal of Financial Economics*, *141*(3), 1244-1261.

Liberti, J. M., & Petersen, M. A. (2019). Information: Hard and soft. *Review of Corporate Finance Studies*, *8*(1), 1-41.

Martinez-Peria, M. S., & Mody, A. (2004). How foreign participation and market concentration impact bank spreads: Evidence from Latin America. *Journal of Money, Credit and Banking*, *36*(3), 511-537.

Mian, A. (2006). Distance constraints: The limits of foreign lending in poor economies. *The Journal of Finance*, *61*(3), 1465-1505.

Modi, K., Pierri, N., Timmer, Y., Soledad, M., & Peria, M. (2022). *The Anatomy of Banks' IT Investments.* International Monetary Fund. *Available at* https://www.imf.org/-/media/Files/Publications/WP/2022/English/wpiea2022244-print-pdf.ashx

Nguyen, H. L. Q. (2019). Are credit markets still local? Evidence from bank branch closings. *American Economic Journal: Applied Economics*, *11*(1), 1-32.

Petersen, M. A., & Rajan, R. G. (2002). Does distance still matter? The information revolution in small business lending. *The Journal of Finance*, *57*(6), 2533-2570.

Pierri, N., & Timmer, Y. (2022). The importance of technology in banking during a crisis. *Journal of Monetary Economics*, *128*, 88-104.

Puri, M., Rocholl, J., & Steffen, S. (2011). Global retail lending in the aftermath of the US financial crisis: Distinguishing between supply and demand effects. *Journal of Financial Economics*, *100*(3), 556-578.

Puri, M., Rocholl, J., & Steffen, S. (2017). What do a million observations have to say about loan defaults? Opening the black box of relationships. *Journal of Financial Intermediation*, *31*, 1-15.

Rajan, U., Seru, A., & Vig, V. (2015). The failure of models that predict failure: Distance, incentives, and defaults. *Journal of Financial Economics*, *115*(2), 237-260.

Sengupta, R. (2007). Foreign entry and bank competition. *Journal of Financial Economics*, *84*(2), 502-528.

Srinivas, V., & Ross, A. (2018). Accelerating digital transformation in banking. *Deloitte. 2018. October, 09. URL: https://www2. deloitte. com/us/en/insights/industry/financial-services/digital-transformation-in-banking-globalcustomer-survey*.

Stein, J. C. (2002). Information production and capital allocation: Decentralized versus hierarchical firms. *The Journal of Finance*, *57*(5), 1891-1921.

Stiroh, K. J. (2006). A portfolio view of banking with interest and noninterest activities. *Journal of Money, Credit and Banking*, *38*(5), 1351-1361.

Tang, H. (2019). Peer-to-peer lenders versus banks: substitutes or complements?. *The Review of Financial Studies*, *32*(5), 1900-1938.

Vives, X., & Ye, Z. (2022). *Fintech Entry, Lending Market Competition and Welfare*. Working Paper IESE Business School, July 14.

Vives, X., & Ye, Z. (2023). Information technology and lender competition. *Available at SSRN 3863988.*

Wu, J., Chen, M., Jeon, B. N., & Wang, R. (2017). Does foreign bank penetration affect the risk of domestic banks? Evidence from emerging economies. *Journal of Financial Stability*, *31*, 45-61.

Figure 1 The Evolvement of Bank MAUs

The bar chart illustrates the total Monthly Active Users (MAU) of all banks for each year (left Y-axis), while the line graph shows the percentage of MAU contributed by the 18 national banks (right Y-axis). The solid line represents the average of nationwide banks' MAU shares across all provinces, whereas the dashed line indicates nationwide banks' MAU share over the country, calculated as nationwide banks' MAU divided by the total MAU of all banks in China.

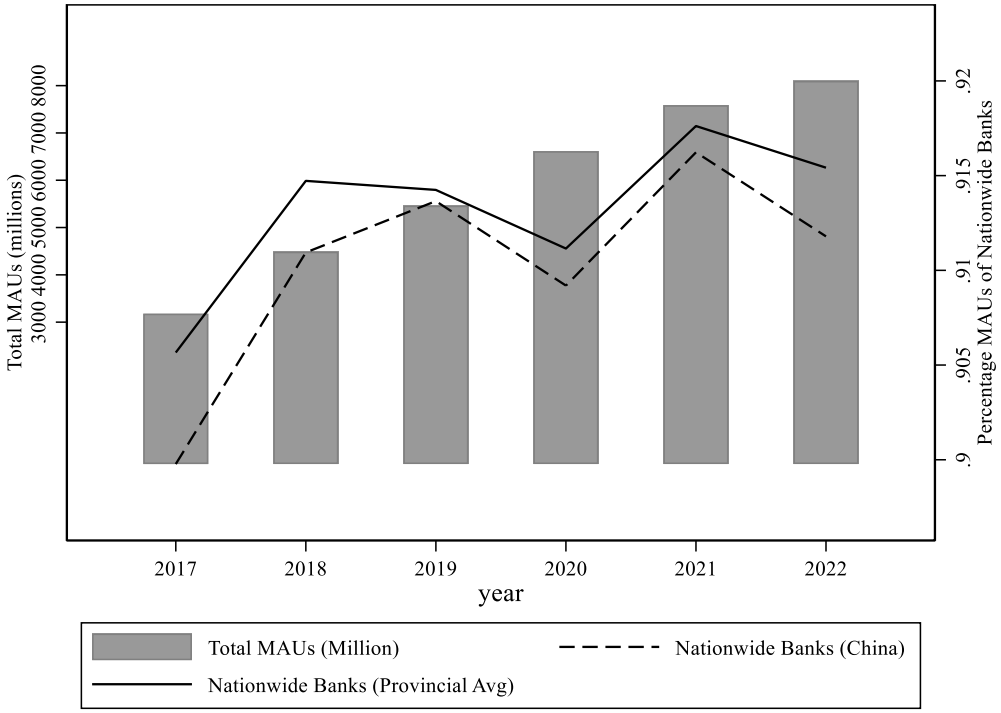


Table 1 Distribution of Digital Competition cross China

The table presents descriptive information about banks' digital competition across China's 31 provinces. The first three columns report the total MAU, and the percentage of MAU contributed by national banks or the Big 6 banks. The next two columns present the number of banks and the percentage of nationwide banks across provinces. The last two columns provide a direct measure of digital banking competition, represented by the HHI for the years 2022 and 2017.

Province	***MAU***			***# of Banks***		***HHI***	
	2022 Total	*Nationwide Bank*	*Big 6 Bank*	*Total #*	*% of nationwide banks*	*2022*	*2017*
Shanghai	320.859	90.917%	56.171%	20	90.000%	0.104	0.114
Beijing	357.763	86.445%	56.834%	20	90.000%	0.115	0.139
Guangdong	977.020	95.004%	61.532%	106	16.981%	0.111	0.113
Zhejiang	641.481	90.947%	68.806%	114	15.789%	0.124	0.133
Shandong	521.940	91.973%	66.910%	142	12.676%	0.109	0.125
Jiangsu	696.259	78.870%	59.427%	83	21.687%	0.087	0.093
Fujian	333.748	96.553%	62.603%	50	36.000%	0.109	0.139
Tianjin	154.111	89.297%	62.677%	21	85.714%	0.114	0.119
Jiangxi	186.238	94.704%	72.324%	104	17.308%	0.124	0.156
Hainan	44.007	92.436%	60.406%	28	64.286%	0.102	0.150
Hebei	302.376	93.328%	77.929%	98	18.367%	0.135	0.170
Shanxi	188.808	95.735%	71.371%	120	15.000%	0.120	0.162
Liaoning	279.139	94.989%	66.340%	61	29.508%	0.116	0.132
Hubei	280.116	95.614%	70.107%	96	18.750%	0.125	0.158
Chongqing	242.214	80.611%	56.098%	21	85.714%	0.108	0.121
Shaanxi	214.156	94.404%	61.309%	77	23.377%	0.105	0.128
Heilongjiang	154.343	94.106%	74.133%	83	21.687%	0.127	0.170
Hunan	288.012	91.393%	67.021%	120	15.000%	0.108	0.147
Henan	407.534	92.473%	69.288%	126	14.286%	0.103	0.115
Sichuan	388.287	93.018%	73.418%	103	17.476%	0.124	0.155
Guangxi	139.377	90.552%	68.445%	77	23.377%	0.106	0.154
Anhui	259.015	87.486%	68.636%	101	17.822%	0.104	0.126
Xinjiang	93.339	94.289%	75.378%	54	33.333%	0.137	0.194
Inner	118.326	96.113%	73.421%	68	26.471%	0.125	0.167
Jilin	120.692	94.952%	78.047%	58	31.034%	0.142	0.193
Yunnan	153.286	95.908%	64.088%	103	17.476%	0.109	0.155
Guizhou	78.936	90.068%	69.002%	82	21.951%	0.120	0.172
Gansu	81.656	88.258%	68.101%	58	31.034%	0.110	0.183
Ningxia	41.535	84.740%	66.904%	40	45.000%	0.106	0.152
Qinghai	21.946	92.384%	69.968%	52	34.615%	0.123	0.223
Tibet	13.509	90.284%	75.202%	19	94.737%	0.152	0.131

Table 2 Summary Statistics

Panel A and Panel B present bank-level and province-level key variables, respectively. Panel C compares the performance and characteristics between nationwide banks and regional banks. The last two columns of Panel C display the difference in means and medians with t-test and signrank test significance, respectively. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. The definition of all variables is presented in Appendix 1.

Panel A Bank-level Variables

Variable	*N*	*Mean*	*SD*	*P5*	*Median*	*P95*
NTINCTA	1436	0.007	0.004	0.002	0.007	0.014
NIM	1416	0.025	0.009	0.010	0.025	0.041
PVCRA	1295	2.650	1.488	1.306	2.084	5.886
Z-score	1338	4.604	0.979	3.106	4.578	6.259
FINATA	1435	0.082	0.082	0.000	0.060	0.243
OHTA	1415	0.009	0.003	0.005	0.009	0.015
LTA	1442	0.508	0.102	0.328	0.516	0.668
Asset	1450	24.970	1.339	22.770	24.910	27.230
CAR	1432	13.940	2.179	11.120	13.640	17.880

Panel B Province-level Variables

Variable	*N*	*Mean*	*SD*	*P5*	*Median*	*P95*
HHI	186	0.125	0.022	0.101	0.121	0.168
CR_6	186	0.685	0.066	0.581	0.687	0.784
PGDP	186	11.01	0.398	10.46	10.93	11.82
GGDP	186	0.089	0.045	0.014	0.090	0.157

Panel C Differences between Nationwide and Regional Banks

Variables	**Nationwide Banks**		**Regional Banks**		**Test for Difference**	
	Mean	*Median*	*Mean*	*Median*	*Mean-Diff*	*Median-Diff*
NTINCTA	0.008	0.008	0.007	0.007	0.001*	0.000**
NIM	0.025	0.026	0.025	0.025	0.000	0.001
PVCRA	2.105	1.822	2.650	2.084	-0.545***	-0.262***
Z-score	5.427	5.408	4.604	4.578	0.823***	0.830***
FINATA	0.066	0.060	0.082	0.060	-0.016*	0.000
OHTA	0.008	0.007	0.009	0.009	-0.001***	-0.002***
LTA	0.534	0.556	0.508	0.516	0.026**	0.040***
Asset	29.526	29.535	24.973	24.913	4.553***	4.622***
CAR	13.677	13.380	13.941	13.640	-0.264	-0.260

Table 3 Changes in Regional Banks' Performance

The table present the influence of digital competition on regional banks' performance. The dependent variables are net income to total asset (*NETINCTA*), provision coverage ratio (*PVCRA*), and net interest margin (*NIM*) in the first, middle and last two specifications, respectively. The focal variable is the *HHI* of the regional bank's headquartered province. The full set of control variables along with firm fixed effects and year fixed effects are also included. OLS regression coefficients are reported along with standard errors in parentheses clustered at the bank level. ***, **, * represent statistical significance at the 1%, 5%, and 10% levels, respectively. The definition of variables is presented in Appendix I.

	(1)	(2)	(3)	(4)	(5)	(6)
Y=	*NETINCTA*	*NETINCTA*	*PVCRA*	*PVCRA*	*NIM*	*NIM*
HHI	0.043***	0.048***	16.532***	17.996***	0.071**	0.064**
	(0.012)	(0.011)	(3.968)	(3.900)	(0.028)	(0.028)
OHTA		0.142**		31.170		0.216
		(0.065)		(25.822)		(0.157)
LTA		-0.000		-0.536		0.010**
		(0.002)		(0.623)		(0.004)
Asset		0.000		0.138		0.001*
		(0.001)		(0.101)		(0.001)
CAR		0.000**		0.019		-0.000
		(0.000)		(0.020)		(0.000)
PGDP		0.007**		1.824		-0.014
		(0.003)		(1.222)		(0.010)
GGDP		0.004		0.055		-0.018*
		(0.003)		(1.098)		(0.009)
Constant	0.002	-0.089**	0.719	-23.618	0.017***	0.129
	(0.001)	(0.041)	(0.466)	(14.713)	(0.003)	(0.117)
Bank Effect	YES	YES	YES	YES	YES	YES
Year Effect	YES	YES	YES	YES	YES	YES
Observations	1,416	1,365	1,263	1,221	1,394	1,345
Adj R2	0.761	0.769	0.784	0.785	0.670	0.677

Table 4 Regional Banks' Responses to Digital Competition

The table presents regional banks' response to digital competition. The dependent variables are the *Z-score* in the first two specifications and financial investment to total asset (*FINATA*) in the last two specifications. The focal variable is the *HHI* of the regional bank's headquartered province. The full set of control variables, along with firm fixed effects and year fixed effects, are also included. OLS regression coefficients are reported along with standard errors in parentheses clustered at the bank level. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. The definition of variables is presented in Appendix I.

	(1)	(2)	(3)	(4)
Y=	*Z-score*	*Z-score*	*FINATA*	*FINATA*
HHI	-8.173**	-10.887***	-1.231***	-1.467***
	(3.989)	(3.917)	(0.326)	(0.322)
OHTA		7.586		-0.412
		(28.348)		(1.481)
LTA		-0.578		-0.100**
		(0.674)		(0.040)
Asset		0.573***		-0.015*
		(0.203)		(0.008)
CAR		0.019		0.001
		(0.021)		(0.001)
PGDP		0.177		-0.116
		(1.417)		(0.103)
GGDP		2.528*		0.289***
		(1.417)		(0.097)
Constant	5.585***	-10.733	0.228***	1.943
	(0.466)	(16.351)	(0.038)	(1.205)
Bank Effect	YES	YES	YES	YES
Year Effect	YES	YES	YES	YES
Observations	1,294	1,261	1,431	1,372
Adj R2	0.350	0.365	0.565	0.583

Table 5 Instrumental Variable and 2SLS Approach

This table reports the 2SLS results. The first specification presents the first stage regression results where the dependent variable is HHI, and the Bartik-styled instrumental variables, Hiring-Concentration, reflect the concentration of mobile banking-related hiring in each province. Specifications (2) to (6) present the second stage regression results, where the dependent variables are net income over assets (*NETINCTA*), provision coverage ratio (*PVCRA*), net interest margin (*NIM*), *Z-score*, and bank's financial investment amount over assets (*FINATA*). Control variables, firm fixed effects, and year fixed effects are also incorporated as in the baseline regression. OLS regression coefficients are reported along with standard errors in parentheses clustered at the bank level. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. The definition of variables is presented in Appendix I.

	(1)	(2)	(3)	(4)	(5)	(6)
Y=	*HHI*	*NETINCTA*	*PVCRA*	*NIM*	*Z-score*	*FINATA*
Hiring_Concentration	0.008***					
	(0.001)					
$\widehat{HHI}$	0.008***	0.133*	66.995**	0.544***	-50.821**	-3.052**
	(0.001)	(0.075)	(25.864)	(0.156)	(25.228)	(1.530)
Constant	1.054***	-0.184*	-80.661**	-0.399*	27.193	3.703**
	(0.127)	(0.099)	(31.706)	(0.209)	(26.811)	(1.876)
Controls	YES	YES	YES	YES	YES	YES
Bank Effect	YES	YES	YES	YES	YES	YES
Year Effect	YES	YES	YES	YES	YES	YES
Observations	1,365	1,365	1,221	1,345	1,261	1,372
R-squared	0.928	0.814	0.829	0.747	0.499	0.664
KP Wald F-Stats		45.86	33.82	43.55	41.38	45.73
Stock-Yogo threshold		16.38	16.38	16.38	16.38	16.38

Table 6 Digital Competition and Stability

The table presents the influence of digital competition on regional banks' stability. Panel A focuses on the percentage of closed branches of each bank in a given year (*CLOSURE*). Panel B focuses on the number of scrutiny incidents received by each bank in a given year, rescaled by the number of employees (*SCRUTINY*). The first two specifications of each panel report the OLS regression results, while specifications (3) and (4) present the 2SLS regression results. Regression coefficients are reported along with standard errors in parentheses clustered at the bank level. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. The definition of variables is presented in Appendix I.

Panel A Bank Closure

	(1)	(2)	(3)	(4)
Y=	*CLOSURE*	*CLOSURE*	*HHI*	*CLOSURE*
HHI	-0.109**	-0.140**		
	(0.053)	(0.054)		
Hiring_Concentration			0.008***	
			(0.001)	
$\widehat{HHI}$				-1.216**
				(0.522)
Constant	0.019***	0.405***	0.999***	1.507**
	(0.006)	(0.154)	(0.120)	(0.616)
Controls	NO	YES	YES	YES
Bank Effect	YES	YES	YES	YES
Year Effect	YES	YES	YES	YES
Observations	1,090	1,054	1,054	1,054
R-squared	0.836	0.840	0.941	0.846
KP Wald F-Stats				34.47
Stock-Yogo threshold				16.38

Panel B Bank Scrutiny

	(1)	(2)	(3)	(4)
Y=	*SCRUTINY*	*SCRUTINY*	*HHI*	*SCRUTINY*
HHI ($\widehat{HHI}$)	-0.011*	-0.015**		-0.069*
	(0.006)	(0.007)		(0.038)
Hiring_Concentration			0.009***	
			(0.002)	
Constant	0.002***	0.026	1.176***	0.093*
	(0.001)	(0.024)	(0.146)	(0.049)
Controls	NO	YES	YES	YES
Bank Effect	YES	YES	YES	YES
Year Effect	YES	YES	YES	YES
Observations	1,193	1,193	1,193	1,193
R-squared	0.418	0.422	0.936	0.421
KP Wald F-Stats				34.02
Stock-Yogo threshold				16.38

Table 7 Digital Competition and Growth

The table relates digital competition to regional credit supply. The dependent variables are the bank loan amount and consumer loan amount outstanding in each province (in 10 thousand RMB), rescaled by provincial population. The full set of provincial-level control variables, along with province fixed effects and year fixed effects, are included. OLS regression coefficients are reported along with standard errors in parentheses clustered at the province level. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. The definition of variables is presented in Appendix I.

	(1)	(2)	(3)	(4)
Y=	*LoanAMT*	*LoanAMT*	*CLoanAMT*	*CLoanAMT*
HHI	0.644***	0.624***	0.180**	0.181**
	(0.228)	(0.180)	(0.076)	(0.071)
PGDP		-0.045		-0.024
		(0.055)		(0.016)
GGDP		0.009		-0.001
		(0.046)		(0.013)
GIND		0.047		-0.015
		(0.138)		(0.031)
GPRICE		-0.002		0.000
		(0.002)		(0.001)
GINVEST		0.003		-0.001
		(0.012)		(0.004)
Market		0.008*		0.001
		(0.004)		(0.001)
Constant	0.040	0.638	0.006	0.261
	(0.028)	(0.650)	(0.010)	(0.189)
Province Effect	YES	YES	YES	YES
Year Effect	YES	YES	YES	YES
Observations	186	186	186	186
Adj R2	0.971	0.973	0.979	0.979

Table 8 Alternative Measures of Competition

This table uses alternative measures of digital banking competition. The dependent variable in Panel A is the weighted HHI for each bank (*W_HHI*), and Panel B uses the MAU concentration ratio of each province (*CR_6*). The full set of control variables, along with bank fixed effects and year fixed effects, are also included. OLS regression coefficients are reported along with standard errors in parentheses clustered at the firm level. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. The definition of variables is presented in Appendix I.

Panel A Weighted HHI

	(1)	(2)	(3)	(4)	(5)
VARIABLES	*NETINCTA*	*PVCRA*	*NIM*	*Z-score*	*FINATA*
W_HHI	0.059***	21.678***	0.056*	-11.744**	-1.498***
	(0.012)	(4.934)	(0.032)	(5.007)	(0.404)
Constant	-0.081*	-36.585**	0.075	-5.233	1.915
	(0.043)	(15.220)	(0.129)	(16.863)	(1.344)
Controls	YES	YES	YES	YES	YES
Bank Effect	YES	YES	YES	YES	YES
Year Effect	YES	YES	YES	YES	YES
Observations	1,194	1,068	1,165	1,101	1,201
R-squared	0.818	0.840	0.741	0.504	0.669

Panel B Concentration Ratio

	(1)	(2)	(3)	(4)	(5)
VARIABLES	*NETINCTA*	*PVCRA*	*NIM*	*Z-score*	*FINATA*
CR_6	0.013***	4.072**	0.053***	-4.553***	-0.354**
	(0.005)	(2.022)	(0.013)	(1.605)	(0.146)
Constant	-0.074*	-14.954	0.045	-8.578	1.352
	(0.041)	(14.016)	(0.118)	(17.175)	(1.172)
Controls	YES	YES	YES	YES	YES
Bank Effect	YES	YES	YES	YES	YES
Year Effect	YES	YES	YES	YES	YES
Observations	1,365	1,221	1,345	1,261	1,372
R-squared	0.815	0.829	0.750	0.501	0.665

Table 9 Alternative measures of performance and responses

This table uses alternative measures for bank performance and responses. The dependent variables are a bank's Return on Equity (*ROE*), non-performing loan ratio (*NPL*), standard deviation of Return on Assets (*SD_NETINCTA*), and the loan amount growth (*GLOAN*). The full set of control variables, along with bank fixed effects and year fixed effects, are also included. OLS regression coefficients are reported along with standard errors in parentheses clustered at the firm level. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. The definition of variables is presented in Appendix I.

	(1)	(2)	(3)	(4)
VARIABLES	*ROE*	*NPL*	*SD_NETINCTA*	*GLOAN*
HHI	0.481*	-10.893**	0.014***	1.251**
	(0.288)	(4.226)	(0.005)	(0.526)
OHTA	3.013	-18.206	-0.051	-0.020
	(2.139)	(26.884)	(0.034)	(3.590)
LTA	0.007	1.906**	0.002*	-0.597***
	(0.054)	(0.955)	(0.001)	(0.114)
Asset	0.006	-0.112	-0.001***	-0.073**
	(0.012)	(0.154)	(0.000)	(0.032)
CAR	0.000	-0.040	-0.000	-0.001
	(0.002)	(0.031)	(0.000)	(0.005)
PGDP	0.358***	-2.367*	-0.002	-0.270*
	(0.099)	(1.430)	(0.002)	(0.138)
GGDP	0.259**	-0.649	-0.002	-0.283
	(0.101)	(1.206)	(0.002)	(0.179)
Constant	-4.086***	32.395*	0.048**	5.217***
	(1.179)	(16.569)	(0.020)	(1.794)
Bank Effect	YES	YES	YES	YES
Year Effect	YES	YES	YES	YES
Observations	1,300	1,327	1,273	1,313
R-squared	0.700	0.737	0.575	0.358

Appendix I Variable Definition

Bank-level variables	
NTINCTA	Net income over assets of a bank in a given year.
NIM	Net interest margin of a bank in a given year.
PVCRA	Provision coverage ratio of a bank in a given year.
Z-score	Z-score of each bank in a given year, defined as $\ln\left(\frac{\text{NETINCTA}+\frac{\text{Equity}}{\text{Asset}}}{\sigma(\text{NETINCTA})}\right)$, where $\sigma(\text{NETINCTA})$ is the standard deviation of annual ROA over the past three years.
FINATA	The proportion of a bank's financial assets to total assets in a given year, including trading financial assets, derivative financial assets, available-for-sale financial assets, long-term equity investments, and investment properties.
OHTA	Overhead costs to total assets of a bank in a given year.
LTA	Loan to assets of a bank in a given year.
Asset	The natural logarithm of bank assets in a given year.
CAR	Capital adequacy ratio of a bank in a given year.
CLOSURE	The percentage of branches closed by each bank in a given year.
SCRUTINY	Number of scrutinies from regulators received by each bank in a given year, rescaled by the number of employees.
W_HHI	The weighted average of the competition index (HHI) for a bank in a given year, calculated as $W_HHI_{it} = \sum_p \frac{MAU_{pt}}{MAU_{it}} * HHI_{pt}$, where the weights are the bank's MAU share in a given province.
ROE	Return on equity of a bank in a given year.
NPL	The non-performing loans ratio of a bank in a given year.
SD_NETINCTA	The standard deviation of net income to total assets over the past three years.
GLOAN	The growth rate of loans of a bank in a given year.
Province-level variables	
HHI	The Herfindahl-Hirschman Index (HHI) of MAUs in each province in a given year.
CR_6	The combined MAU share of the Big 6 banks in a province in a given year.
PGDP	Provincial GDP per capita.
GGDP	The growth rate of GDP.
Hiring_Concentration	The concentration measure of mobile banking-related hiring in each province-year.
LoanAmt	The total outstanding bank loan amount in a province rescaled by provincial population (RMB 10K/person).
CLoanAmt	The total outstanding consumer loan amount in a province rescaled by provincial population (RMB 10K/person).
GIND	The value added of the tertiary industry over GDP.
GPRICE	The growth rate of prices in each province.
GINVEST	The growth rate of fixed asset investment.
Market	The NERI marketization index of each province in a given year. A higher value indicates a greater regional marketization level.

Appendix II Key words in Selecting Mobile-bank-related Jobs

This table summarizes the mobile banking related key words.

Mobile Payment, NFC Payment, Smart Wearables, Mobile Connectivity, Internet of Things (IoT), Smart Sensors, Electronic Tagging, Digital Identity, Cybersecurity, Data Encryption, Fingerprint Recognition, Facial Recognition, Voiceprint Recognition, Intelligent Marketing, Digital Marketing, Unmanned Retail, Third-Party Payment, Network Clearing (Wanglian), Intelligent Customer Service, Customer Relationship Management (CRM), Risk Assessment, Fraud Management, 5G.